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C. S. DEMAREST

REPEATER ARRANGEMENT FOR MULTIPLEX SIGNALING

Filed Sept. 13, 1919

3 Sheets-Sheet 1

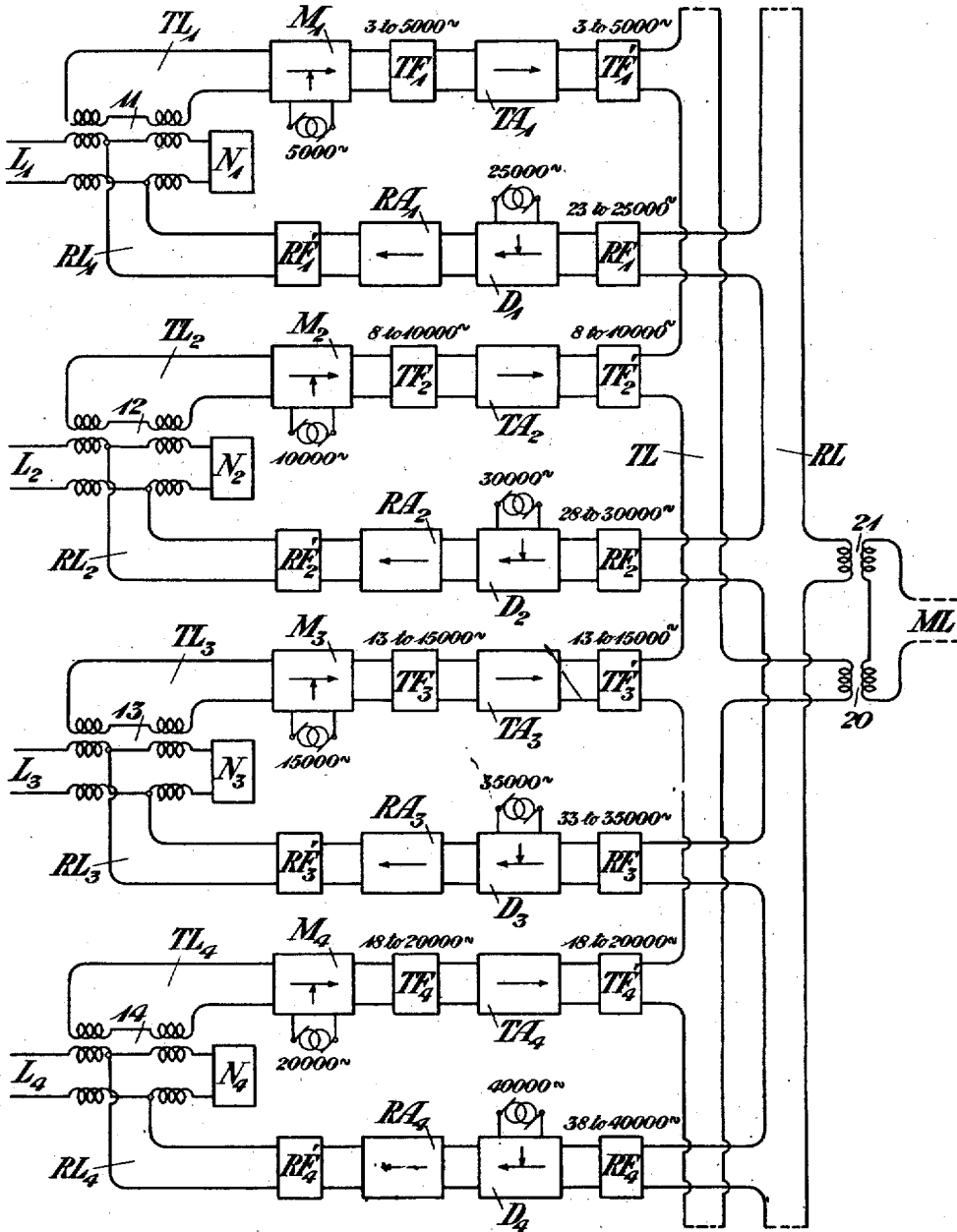


Fig. 1

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3 Sheets-Sheet 2

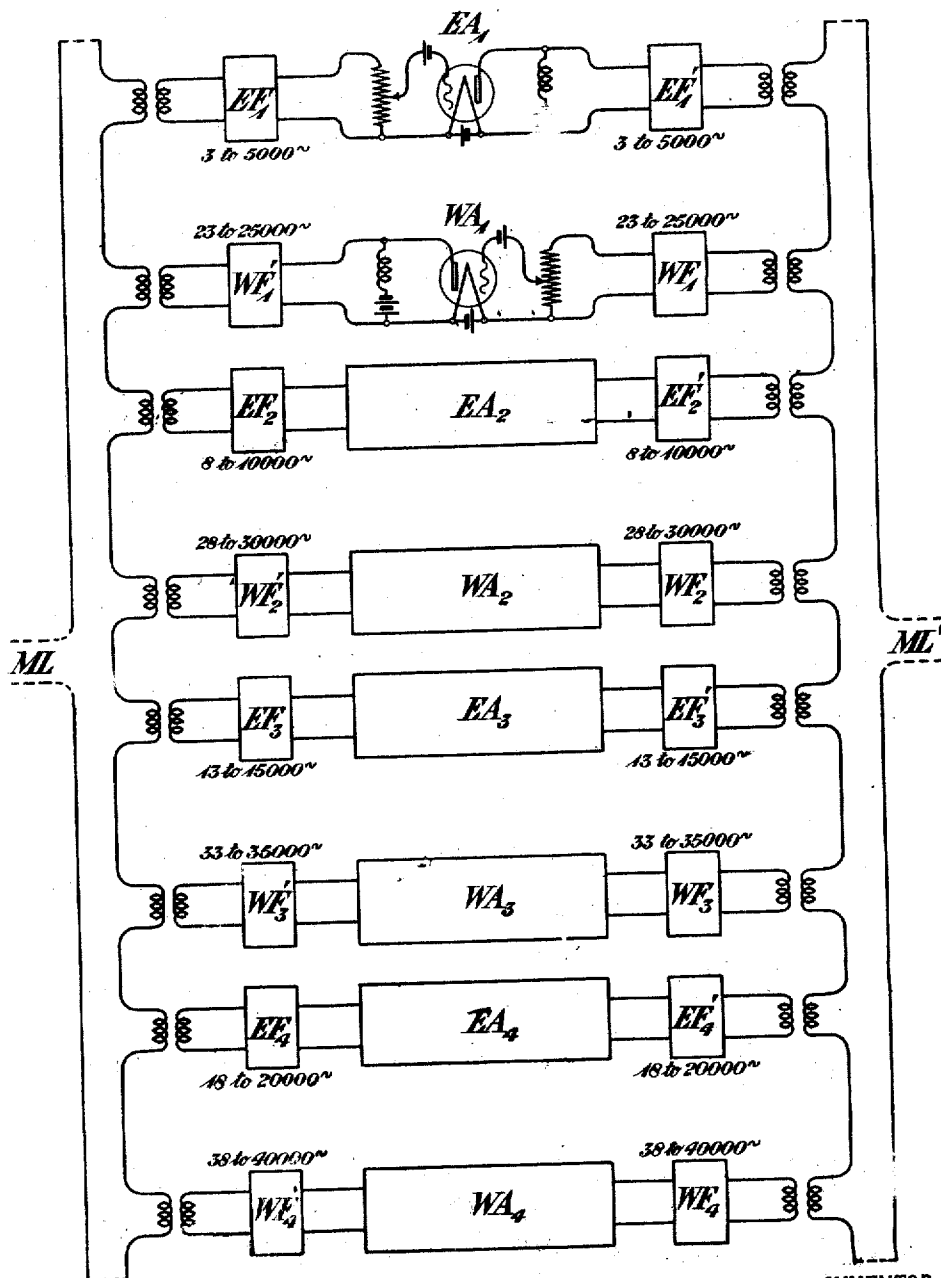


Fig. 2

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3 Sheets-Sheet 3

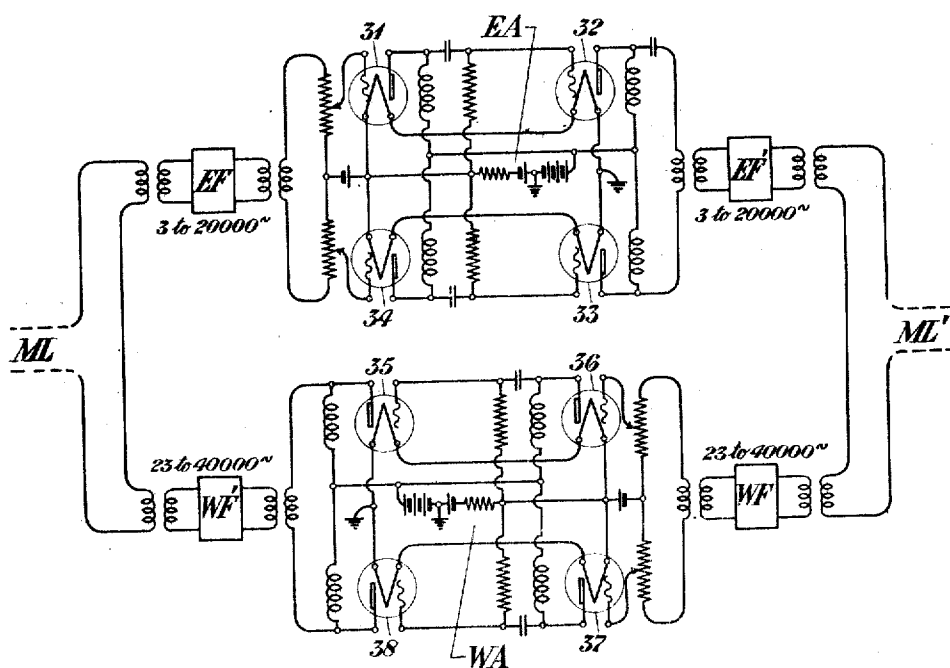


Fig. 3

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Patented Jan. 29, 1924.

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UNITED STATES PATENT OFFICE.

CHARLES S. DEMAREST, OF BROOKLYN, NEW YORK. ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

REPEATER ARRANGEMENT FOR MULTIPLEX SIGNALING.

Application filed September 13, 1919. Serial No. 323,492.

To all whom it may concern:

Be it known that I, CHARLES S. DEMAREST, residing at Brooklyn, in the county of Kings and State of New York, have invented certain Improvements in Repeater Arrangements for Multiplex Signaling, of which the following is a specification.

This invention relates to signaling systems and more particularly to repeating apparatus for such systems.

One of the main features of the invention is the provision of a repeating apparatus of such character that the balancing equipment usually provided in connection with two-way repeaters may be eliminated.

Another feature of the invention relates to the provision of a repeating system in which transmission in opposite directions takes place at different frequencies, with such an arrangement of the repeaters that frequencies transmitted in one direction are amplified by one repeater or set of repeaters only, while frequencies transmitted in the opposite direction are amplified by another repeater or set of repeaters only.

Another feature of the invention is the provision of such an arrangement of repeaters that the transmission and amplification of each range of frequencies can be regulated independently.

Still another feature of the invention is the provision of a repeater arrangement for a multiple frequency system of such character that the range of operation may be increased without singeing.

These results, as well as other aims of the invention, which will be clear from the detailed description hereinafter appearing, are realized in a system in which one or more signals simultaneously transmitted in one direction utilize a plurality of carrier frequencies lying within one range, while one or more signals simultaneously transmitted in the opposite direction utilize a corresponding number of carrier frequencies lying within another range. In order to amplify the oppositely directed transmission one-way repeating apparatus (which may comprise a single repeater unit or separate repeater units for amplifying the frequencies of different signals transmitted in the same direction) is provided for the purpose

of amplifying frequencies within the range utilized for transmission in one direction. By associating properly designed filters with the repeating apparatus, frequencies transmitted in the opposite direction will be prevented from reacting upon this one-way repeating apparatus, so that it is possible to directly associate the input and output circuits of the two sets of repeating apparatus for repeating in opposite directions, without using artificial lines or balancing networks to prevent singeing.

The invention may now be more fully understood from the following description, when read in connection with the accompanying drawing, Figures 1 and 2 of which, when taken together, constitute a circuit diagram of one embodiment of the invention and Figs. 1 and 3 of which, when taken together, constitute a circuit diagram of another embodiment of the invention.

Referring to Figs. 1 and 2, ML designates a transmission line terminating in carrier apparatus, as shown in Fig. 1. The terminal carrier apparatus is of a well-known character and is not a part of the present invention, so that consequently it is merely illustrated in schematic form. L_1 , L_2 , L_3 and L_4 designate signaling circuits from which signals may be simultaneously transmitted over the main line ML. The signals transmitted over these lines may be telephonic, telegraphic or of any other character which it is desired to transmit, and the number of signaling circuits may vary as circumstances may require. The line L_1 is associated with a carrier transmitting circuit TL_1 and a carrier receiving circuit RI_1 , through a balanced transformer arrangement 11, said circuits being rendered conjugate, so that disturbances in the one do not affect the other, by balancing the line L_1 by means of an artificial line or net work N_1 . In a similar manner line L_2 is associated with circuits TL_2 and RI_2 ; line L_3 is associated with TL_3 and RI_3 , and line L_4 is associated with circuits TL_4 and RI_4 .

In order to translate the signals incoming from the lines L_1 , L_2 , etc., into carrier currents, modulators M_1 , M_2 , M_3 and M_4 are provided, each modulator being supplied by a source of carrier currents, the several

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sources being of different frequencies. As illustrated, the frequencies of the several modulators are 5,000, 10,000, 15,000 and 20,000 cycles respectively. These modulators may be of any well-known type, but are preferably modulators of the well-known vacuum tube type.

The filters TF_1 and TF_1' are also provided in the circuit TL_1 , while an amplifier TA_1 is connected between said filters. These filters are preferably of the type disclosed in the U. S. Patents to George A. Campbell, 1,227,113 and 1,227,114, dated May 22, 1917, and are so designed as to transmit a range of frequencies in the vicinity of the basic carrier frequency assigned to the channel, said range having a width sufficient to take care of the frequency variation due to the low frequency signals. The amplifier TA_1 may be of any well-known type, but is preferably a vacuum tube amplifier such as is well-known in the art. Similar filters and amplifiers are provided in the circuits TL_2 , TL_3 and TL_4 , except that the range of frequencies transmitted by the filters in the different circuits will depend upon the basic frequency assigned to the channel.

The receiving channel RL_1 includes filters RF_1 and RF_1' , demodulator or detector D_1 and amplifier RA_1 . The demodulator or detector D_1 may be of any well-known character, but is preferably a detector of the vacuum tube type, employing the homodyne method of receiving. The demodulator or detector is therefore supplied with oscillations from a local source, having the same frequency as the basic frequency of the modulated received oscillations. In the case illustrated, the frequency assigned to the channel and therefore the frequency of the local source is 25,000 cycles. The filters RF_1 and RF_1' are similar to the corresponding filters of the transmitting channel, except that the range of frequencies transmitted by the former is in the neighborhood of 25,000 cycles, instead of in the neighborhood of 5,000 cycles, while filters RF_1' is a low pass filter transmitting only signaling frequencies. It will thus be seen that the transmitting and receiving channels operate at different frequencies, so that frequency separation as well as balance is available to prevent inter-action of the transmitting and receiving circuits. The amplifier RA_1 is similar in all respects to the amplifier TA_1 , except that it is designed for amplifying low frequencies. Similar filtering, demodulating and amplifying arrangements are provided for the other receiving channels RL_2 , RL_3 and RL_4 . Basic frequencies assigned to the other channels are, however, as illustrated, 30,000, 35,000 and 40,000 cycles for the receiving channels RL_2 , RL_3 and RL_4 , respectively. It will be observed that, as illustrated all of the frequencies

used for transmitting lie in a range between 3,000 and 20,000 cycles, while the frequencies used for reception lie between 23,000 and 40,000 cycles. This provides a very considerable frequency separation between corresponding transmitting and receiving channels of the same low frequency signaling circuit.

The transmitting channels TL_1 , TL_2 , TL_3 and TL_4 are associated with a common transmitting circuit TL and in a similar manner the receiving channels RL_1 , RL_2 , RL_3 and RL_4 are associated with a common receiving circuit RL . The circuits TL and RL are associated with the main line ML through transformers 20 and 21, so that the transmission from the several channels may simultaneously take place over the main line.

One form of amplifying arrangement is illustrated in Fig. 2, in which the main line ML is connected to the main line section ML' by means of a plurality of repeaters EA_1 , EA_2 , EA_3 and EA_4 , for amplifying transmission from west to east, a similar set of one-way repeaters WA_1 , WA_2 , WA_3 and WA_4 being provided for amplifying transmissions from east to west. Each of these repeaters is preferably a vacuum tube repeater of well-known type, as illustrated in connection with the repeaters EA_1 and WA_1 , the remaining repeaters being merely illustrated schematically. Filters are provided in the input and output circuits of each one-way repeater for determining the frequencies which will be transmitted to the repeater for amplification. Thus the amplifier EA_1 is provided with filters EF_1 and EF_1' , in its input and output circuits, respectively, these filters being of the general character described in the patents to Campbell aforementioned, and being so designed as to transmit a range of frequencies, for example from 3,000 to 5,000 cycles, which, it will be noted, corresponds to the frequencies used in transmitting from the transmitting channel TL_1 of Fig. 1. The corresponding repeater WA_1 for repeating in the opposite direction, is likewise provided with filters WF_1 and WF_1' of the same general type, but in this instance the range of frequencies transmitted is illustrated as being from 23,000 to 25,000 cycles, corresponding to the range of frequencies assigned to the receiving circuit RL_1 of Fig. 1. Similar filters are provided for all of the other one-way repeaters, as indicated, and in each instance the frequency range of the filters will correspond to the frequency range of a corresponding transmitting or receiving channel at the station of Fig. 1.

The line ML' will, of course, terminate in carrier apparatus similar to that shown in Fig. 1, but for simplicity of illustration the carrier apparatus at the other station is not illustrated, as it is not necessary for a

complete understanding of the invention. The operation is as follows:

Signals incoming from the line L_1 are transmitted to the transmitting channel TL_1 through the transformer 11, modulating the carrier frequency of 5,000 cycles by means of the modulator M_1 . The modulated frequencies are transmitted through the filter TF_1 , amplified by the amplifier TA_1 , and then passed through the filter TF_1' to the common transmitting circuit TL . At the same time similar operations may take place with respect to the circuits L_2 , L_3 and L_4 . The several modulated frequencies are now impressed through the transformer 20 upon the main line ML and are transmitted to the repeater apparatus of Fig. 2. The modulated frequencies incoming from the transmitting channel TL_1 are selected by means of the filter EF_1 , amplified by the amplifier EA_1 , and then passed through the filter EF_1' to the main line ML' . In a similar manner the modulated frequencies from the other transmitting channels are selected and amplified by the circuits of the amplifiers EA_2 , EA_3 and EA_4 .

Signals from the distant station (not shown) associated with the main line ML' are translated into frequencies lying in a range from 23,000 to 40,000 cycles and are transmitted over the main line ML' to the repeater apparatus of Fig. 2. Modulated currents corresponding to one transmitting channel at the distant station are passed by the filter WF_1 , amplified by the amplifier WA_1 , and passed through the filter WF_1' for transmission over the main line ML ; other frequencies pass through the circuits of repeaters WA_2 , WA_3 and WA_4 . Upon arriving at the station of Fig. 1 the several frequencies are transmitted through the transformer 21 to the receiving circuit RL_1 , from which they are separated through the filters RF_1 , RF_2 , etc., of the receiving channels. The modulated frequencies between 23,000 and 25,000 cycles are impressed upon the detector D_1 and are thereby translated into low frequency signals which are amplified by the amplifier RA_1 and passed through the low pass filter RF_1' to the line L_1 . The operations in connection with the receiving channels RL_2 , RL_3 and RL_4 are similar to those taking place in connection with the receiving channel RL_1 .

Since the frequencies used in transmitting in one direction lie within an entirely different range from those used for transmitting in the opposite direction, it is possible, by use of a properly designed repeater, to amplify all of the frequencies transmitted in one direction, by means of a common amplifying arrangement. Fig. 3 illustrates an arrangement for this purpose. In this instance the transmission line ML is associated with the transmission line ML' through an

amplifier EA for transmitting from west to east and an amplifier WA for transmitting from east to west. The amplifier EA comprises four vacuum tubes 31 and 32, 33 and 34, arranged in a so-called "push-pull" circuit, so that distortion is practically eliminated. The principles of the push-pull type of repeater are well understood and need not be herein described. Repeater WA similarly comprises amplifying tubes 35, 36, 37 and 38, and is similar in all respects to the repeater EA .

In order to provide proper frequency separation between the repeaters, filters EF and EF' are associated with the input and output circuits of the amplifier EA and filters WF and WF' are similarly associated with the amplifier WA . The filters EF and EF' are arranged to transmit frequencies between 3,000 and 20,000 cycles, so that all of the frequencies incoming from transmitting channels TL_1 , TL_2 , TL_3 and TL_4 of Fig. 1 may be passed to the amplifier EA and amplified thereby. Filters WF and WF' have a range between 23,000 and 40,000 cycles, so that all of the frequencies transmitted in the opposite direction to the receiving channels RL_1 , RL_2 , RL_3 , and RL_4 of Fig. 1 are amplified by the filter WA .

The operation of the arrangement shown in Figs. 1 and 3 will be obvious and need not be further described. It will be seen that no arrangement for balancing the transmission line sections is provided in connection with the repeater arrangement of Fig. 3, since the frequency separation due to the filters is sufficient to prevent singeing over the circuit including the repeaters EA and WA in series. The same statement applies to the repeater arrangements of Fig. 2, in which all of the repeater circuits are separated by means of filters, so that no singeing circuit can be formed through any two repeaters in series.

It will be understood that the frequencies disclosed herein are for purposes of illustration merely and that other frequencies than those shown may be used, if desired. It will be also understood that the signaling channels shown may be utilized for the transmission of signals of any desired character although, as illustrated, the channels are primarily designed for multiplex telephone transmission.

It will also be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated, without departing from the spirit of the invention as defined in the following claims.

What is claimed is:

1. In a signaling system, a transmission line, means for simultaneously transmitting over said line in one direction a plurality

of signals by means of currents of different frequencies, means for simultaneously transmitting in the opposite direction over said line a plurality of signals by means of currents of a plurality of other frequencies, a common repeater in said line for amplifying all of the frequencies transmitted in one direction, and a second common repeater for amplifying all of the frequencies transmitted in the opposite direction.

2. In a signaling system, a transmission line, means for simultaneously transmitting in one direction over said line a plurality of signals by means of currents of a plurality of frequencies lying within one frequency range, means for simultaneously transmitting in the opposite direction over said line a plurality of signals by means of currents of different frequencies lying within another frequency range, a one-way repeater apparatus for amplifying currents transmitted over said line in one direction, a second one-way repeater apparatus for amplifying currents transmitted over said line in the opposite direction, a broad band wave filter associated with said first mentioned repeating apparatus for freely transmitting to the repeater frequencies lying within said first mentioned range, while substantially suppressing frequencies lying without said range, and a second broad band wave filter associated with said second mentioned repeating apparatus for freely transmitting thereto frequencies lying within said second mentioned frequency range, while substantially preventing the transmission of frequencies lying without said range.

3. In a signaling system, in which signals are transmitted in opposite directions by means of currents of different frequencies, a repeater apparatus comprising one-way repeaters for repeating oppositely directed transmissions, the input and output circuits of said one-way repeaters being so associated with each other and with the transmission medium of the system that energy may be freely transmitted from the output circuit of one repeater to the input circuit of the other repeater, and means associated with each one-way repeater for preventing the transmission thereto of energy of frequencies used for the transmission of signals in the direction in which the other repeater amplifies.

4. In a signaling system, a transmission line, means for simultaneously transmitting over said line in one direction a plurality of signals by means of currents of a plurality of frequencies lying within one frequency range, means for simultaneously transmitting over said line in the opposite direction a plurality of signals by means of a plurality of currents of different frequencies lying within another and entirely different frequency range, repeating appa-

atus in said line for amplifying currents within the one frequency range, and another repeating apparatus for transmitting currents lying within the other frequency range.

5. In a signaling system, a transmission line, means for simultaneously transmitting over said line a plurality of signals by means of currents of a plurality of frequencies lying within one frequency range, means for simultaneously transmitting in the opposite direction over said line, a plurality of signals by means of currents of different frequencies lying within another and entirely different frequency range, a common repeater for amplifying all of the frequencies within the first mentioned range, and another common repeater for amplifying all of the frequencies within the second range.

6. In a signaling system a transmission line, means for transmitting one range of frequencies over said line in one direction, means for transmitting another and entirely different range of frequencies over said line in the opposite direction; a two-way repeater in said line comprising a circuit for transmission in one direction, and another circuit for transmission in the opposite direction; an amplifier in each circuit, and selective means in one of said circuits on each side of the amplifier therein, for passing the range of frequencies used in transmitting in one direction, and selective means in the other circuit on each side of the amplifier therein, for selecting the range of frequencies used in transmitting in the opposite direction.

7. In a signaling system a transmission line, means for transmitting one range of frequencies over said line in one direction, means for transmitting another and entirely different range of frequencies over said line in the opposite direction; a two-way repeater in said line, said repeater comprising a circuit for transmission in one direction, and another circuit for transmission in the opposite direction; an amplifier in each circuit; a band filter on each side of the amplifier in one circuit for passing the range of frequencies transmitted in one direction and suppressing the range of frequencies transmitted in the opposite direction, and a band filter on each side of the amplifier in the other circuit for freely transmitting the range of frequencies transmitted in the opposite direction, and for suppressing the frequencies transmitted in the first direction.

8. In a signaling system, transmission line sections, one-way transmission paths between said line sections, means for so interconnecting the ends of said paths and said line sections that transmission may take place from one path to the other upon the

transmission of energy over one of said paths to a line section, frequency selective means to limit to one of said paths a range of frequencies transmitted in one direction over said line sections, and frequency selective means to limit to the other path another and entirely different range of frequencies transmitted in the opposite direction over said lines.

9. In a signaling system, transmission line sections, one-way transmission paths between said line sections, means for so interconnecting the ends of said paths and said line sections that transmission may take place from one path to the other upon the transmission of energy over one of said paths to a line section, a band filter arrangement associated with one of said paths and having a range of free transmission such that frequencies transmitted over said line sections in one direction will be passed into said path to the exclusion of the other path, and a band filter arrangement associated with the other path and having a different range of free transmission such that frequencies transmitted over said line sections in the opposite direction will be transmitted over said paths to the exclusion of said first mentioned path.

10. In a signaling system, transmission line sections over which a plurality of signals may be simultaneously transmitted in both directions, a circuit arrangement associated with said line sections for transmission in one direction, another circuit arrangement associated with said line sections for transmission in the opposite direction, means for so interconnecting said circuit arrangements with said line sections that transmission may take place from one circuit arrangement to the other upon the transmission of energy over one of said circuit arrangements to a line section, means for selecting into one of said circuit arrangements a plurality of signals transmitted over said line sections in one direction, and preventing transmission over said circuit arrangement of signals transmitted in the opposite direction, and means associated with the other circuit arrangement for selecting into the said circuit arrangement a plurality of signals transmitted in the opposite direction, while preventing the transmission over said circuit arrangement of signals transmitted in the said first direction.

11. In a signaling system, transmission line sections, one-way transmission paths between said line sections, means for so interconnecting the ends of said paths and said line sections that transmission may take place from one path to the other upon the transmission of energy over one of said paths to a line section, one-way repeaters in each of said paths, selective means in one of said paths whereby frequencies transmitted

over said line sections in one direction will pass over said path to the exclusion of the other path, and selective means in the other path whereby frequencies transmitted over said line section in the opposite direction will pass over said path to the exclusion of said first mentioned path.

12. In a signaling system, transmission line sections, one-way transmission paths between said line sections, means for so interconnecting the ends of said paths and said line sections that transmission may take place from one path to the other upon the transmission of energy over one of said paths to a line section, one-way repeaters in each path, selective devices in one of said paths on each side of said repeater whereby frequencies transmitted over said line sections in one direction will pass over said path to the exclusion of the other path, and selective means in the other path on each side of the repeater therein whereby frequencies transmitted over said line sections in the opposite direction will pass over said path to the exclusion of said first mentioned path.

13. In a signaling system, transmission line sections, one-way transmission paths between said line sections, means for so interconnecting the ends of said paths and said line sections that transmission may take place from one path to the other upon the transmission of energy over one of said paths to a line section, one-way repeaters in each of said paths and band filters in one of said paths whereby frequencies transmitted over said line sections in one direction will pass over said path to the exclusion of the other path, and band filters in the other path whereby frequencies transmitted over said line sections in the opposite direction will pass over said path to the exclusion of said first mentioned path.

14. In a signaling system, transmission line sections, one-way transmission paths between said line sections, means for so interconnecting the ends of said paths and said line sections that transmission may take place from one path to the other upon the transmission of energy over one of said paths to a line section one-way repeaters in each path, band filters in one of said paths on each side of said repeater whereby frequencies transmitted over said line sections in one direction will pass over said path to the exclusion of the other path, and band filters in the other path on each side of the repeater therein whereby frequencies transmitted over said line sections in the opposite direction will pass over said path to the exclusion of said first mentioned path.

15. In a signaling system, a transmission line section adapted to transmit a plurality of carrier channels in each direction, one-way transmission paths, means for so inter-

connecting the ends of said paths and said line section that transmission may take place from one path to the other upon the transmission of energy over one of said paths to said line section. frequency selective means to limit to one of said paths a range of frequencies corresponding to a plurality of channels transmitting in one direction over said line section. and frequency selective

means to limit to the other path another range of frequencies corresponding to a plurality of channels transmitting in the opposite direction over said line section.

In testimony whereof, I have signed my name to this specification this 12th day of September, 1919.

CHARLES S. DEMAREST.